
Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh

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Chapter 5: Delta Islands

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5 Delta Islands

[Editor's Note: This is an electronic reprint of the original document. The original tables and figures were not available in an electronic format, thus only a few of these tables have been recreated.]

The Division of Planning recently published a report entitled "Estimation of Delta Island Diversions and Return Flows" (Estimation 1995). The report documents the Delta Modeling Section's Delta Island Consumptive Use (DICU) model and associated routines. Several areas for future model enhancement were identified in the above report. Progress in making the identified modifications is documented in this chapter.

Delta Island Water Use Study

A joint feasibility study is being conducted by DWR's Division of Local Assistance and the United States Geological Survey (USGS) under the Municipal Water Quality Investigations (MWQI) program to measure irrigation and drainage volumes, quality, and power consumption on Twitchell Island. After determining the water balance on Twitchell Island, extrapolation methods will be used to estimate the water balance on other Delta islands. Return flows will be calculated using historic power records and pump test data obtained from Pacific Gas and Electric. The DICU model is being used by the study team to prioritize data needs. Data collected from this study will be used to calibrate model parameters. The USGS, under contract with the Delta Modeling Section, will spatially aggregate data in a manner consistent with the DICU model using GIS software.

New Evapotranspiration Formulation

Evapotranspiration (ET) is one of the most significant variables controlling the quantity of both diversions and return flows during the crop growing season. A new method of estimating ET in the Delta was developed by DWR's Central District (*Historic* 1994) and is currently under review. The method is based on an equation which uses temperature and solar radiation to calculate reference ET (*Hargreaves and Samani* 1985). Upon completion of the review process, staff will incorporate the new formulation into the DICU model, replacing the existing formulation based on pan evaporation data.

Channel Diversion Disaggregation

By simulating the relationship between agricultural diversions and entrainment of eggs, larvae, and juvenile fish in the Delta, the DICU model can be used in conjunction with DSM2 hydrodynamics and particle tracking to assess the benefits of managing diversion timing and water use, set priorities on screen placement, and evaluate the benefits associated with relocating or consolidating diversion points. DICU model output was modified to address the significance of agricultural diversions on particle fate and movement by disaggregating channel diversion estimates into two components: siphon inflow and seepage inflow. While disaggregation is not

required to simulate hydrodynamics and water quality, it is essential for simulating particle fate and movement as particles are not entrained by seepage inflows.

Historic Delta Land Use Database

DICU sensitivity analyses demonstrated the importance of land use data in estimating diversion and return flows (*Estimation* 1995). Based on these results, a decision was made to develop a historic Delta land use database. The current version of the DICU model assigns land use to 142 Delta subareas based on D-1485 water year classification. Critical water years are assigned a land use based on a 1976-77 field survey. Non-critical water years are assigned a land use based on various field surveys undertaken in the late 1970s and early 1980s.

This year an extensive search for possible sources of detailed Delta land use data and other pertinent information was conducted. Table 5-1 summarizes the land use data that has been located to date for the period covering 1922 to 1994. A description of this and other information that will be used in database development follows.

Digital Land Use Data and DICU Subarea Boundaries

The USGS, under contract with the Delta Modeling Section, is in the process of digitizing DICU's 142 subarea boundaries. This information will enable staff to access digital land use data that is available through DWR's Statewide Planning Branch. Land use data that is available in digital form is indicated in Table 5-1 with an asterisk.

Other DWR Delta Land Use Data

The DWR Bulletin 23 series (*Report*) contains 13 Delta land use surveys in hard copy format for islands and reclamation districts as shown in Table 3-1. The data cannot be readily digitized but is still very useful as it is aggregated by regions that generally coincide with DICU subareas. The data is currently being keypunched into an electronic file.

The Delta Modeling Section is negotiating another cost-share contract with USGS to digitize the 1968 Delta survey. Also, the Statewide Planning Branch is currently digitizing the 1974 San Joaquin County survey and will schedule additional digitizing work in the future.

The Modeling Support Branch maintains a historic Delta land use database that extends from 1922 through 1992. This database is utilized by DWRSIM's consumptive use model and is aggregated into "uplands" and "lowlands" regions. In recent years, the main sources used to update the database have been DWR surveys and county Agricultural Commissioner's annual reports. Data from the latter source are based, not on field checked land use surveys, but on crop production estimates. Incremental differences in annual crop land use acreages have been used in combination with interpolation methods to update the land use database. This database will be useful in developing a DICU land use database, providing a rational basis for filling in missing data.

USDA Consolidated Farm Service Agency Land Use Data

Each county office of the U.S. Department of Agriculture's Consolidated Farm Service Agency collects land use data on a tract level based on information provided by tract owners. The Sacramento County office has a land use database that extends back at least ten years. Twitchell Island data in Table 3-1 was provided by the Sacramento County office. To obtain complete coverage of the Delta, information must be requested from six county offices.

Table 5-1: Summary of Historic Delta Land Use Surveys

Year	Region	Source (see footnote)	Year	Region	Source (see footnote)
1922			1959		
1923			1960	Twitchell Island	3
1924	Delta Service Area	1	1961	Sacramento County	2
1925	Delta Service Area	1	1962		
1926	Delta Service Area	1	1963		
1927	Delta Service Area	1	1964		
1928	Delta Service Area	1	1965		
1929	Delta Service Area	1	1966		
1930	Delta Service Area	1	1967		
1931	Delta Service Area	1	1968	Delta Service Area	2
1932	Delta Service Area	1	1969		
1933			1970	Contra Costa and Alameda counties	2
1934			1971		
1935			1972	Solano County	2
1936			1973	Yolo County	2
1937			1974	Sacramento and San Joaquin counties	2
1938	Delta Service Area	1	1975		
1939			1976	Delta Service Area	2*
1940			1977		
1941			1978		
1942			1979		
1943			1980	Solano County	2
1944			1981	Yolo County	2
1945			1982	San Joaquin County	2*
1946			1983		
1947			1984	Sacramento County	2
1948	Delta Service Area	1	1985	Contra Costa County	2
1949			1986	Alameda County	2
1950	Delta Service Area	1	1987	Solano County, Twitchell Island	2, 4
1951			1988	San Joaquin County, Twitchell Island	2*, 4
1952			1989	Yolo County, Twitchell Island	2*, 4
1953			1990	Twitchell Island	4
1954			1991	Delta Service Area	2*
1955	Delta Service Area	1	1992	Sherman and Twitchell Island	2*, 4
1956			1993	Sacramento County, Twitchell Island	2*, 4
1957			1994	Solano County, Twitchell Island	2*, 4
1958	San Joaquin County	2			

*Digitized data

¹ DWR, Bulletin 23 Series

² DWR, miscellaneous land use surveys

³ DWR, Own & Nance (1960)

⁴ U.S. Department of Agriculture, Consolidated Farm Service Agency

Return Flow Quality Specification

Subject to further review, representative monthly values for agricultural return quality were developed this year for the following constituents: minerals, electrical conductivity, organic disinfection by-product precursors, biochemical oxygen demand (BOD), nutrients, dissolved oxygen, temperature, and chlorophyll-a (Representative 1995). Much of this preliminary work

was based on aggregated MWQI data provided by DWR's Division of Local Assistance (MWQI 1995). These values will replace DICU's current specification of agricultural return quality, which is based on DWR's Bulletin 123 (Delta 1967) and is limited to total dissolved solids and chloride. Monthly values for minerals, electrical conductivity, BOD, nutrients and chlorophyll-a were aggregated by Bulletin 123 subregion. In general, the remaining values were aggregated by dissolved organic carbon (DOC) subregion as shown in Figure 5-1 (Five-Year 1994).

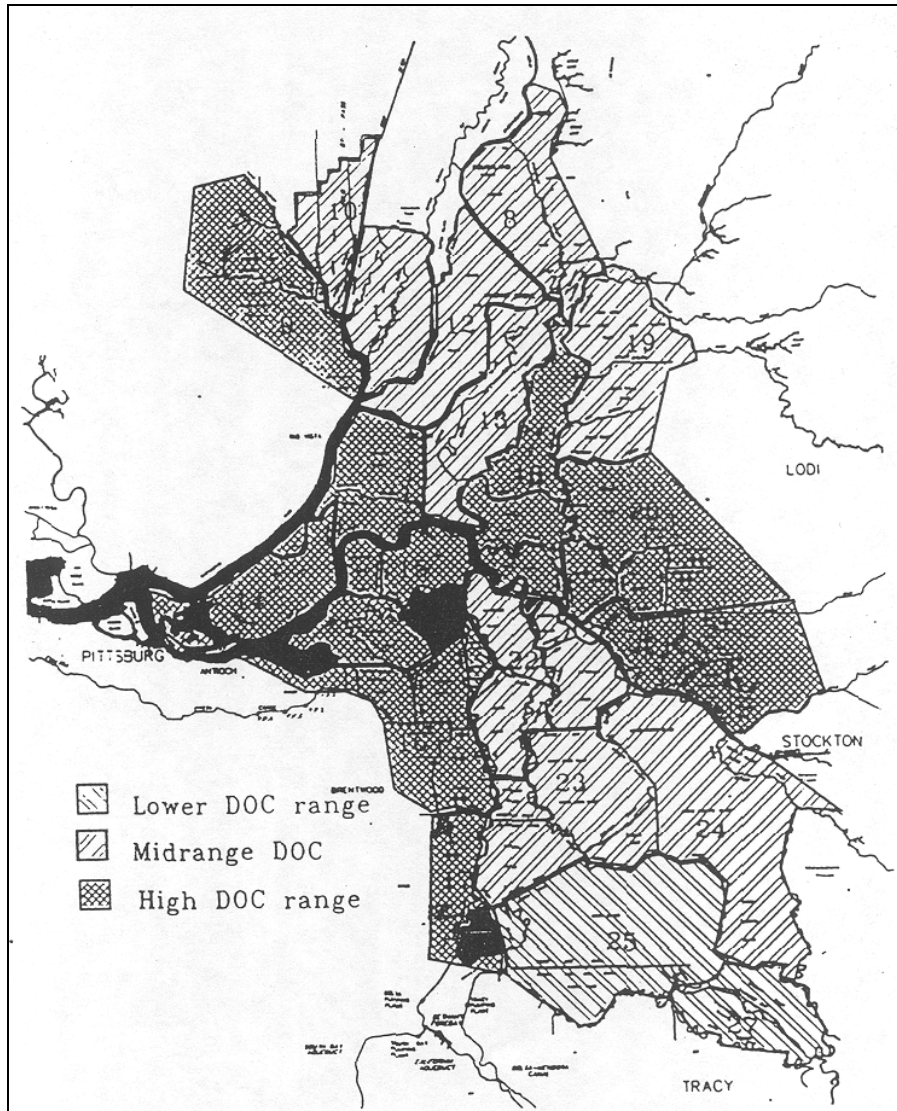


Figure 5-1: Municipal Water Quality Investigations Delta Subregions

Specification of representative values is considered to be an interim solution to modeling agricultural drain quality. A long-term solution is to simulate changes in agricultural return quality with dynamic mathematical formulations. A contract with the University of California, Davis has been executed to expedite the attainment of this goal with respect to salinity and organics.

New Seepage and Irrigation Efficiency Estimates

New spatially varying Delta seepage and irrigation efficiency estimates were developed this year. The current DICU model only accounts for the component of seepage inflow that is available for consumptive use by plants. And currently, a constant Delta-wide irrigation efficiency estimate of 70% is utilized by the model. New estimates, discussed in the following section, are based in part on data from DWR's Report 4 (*Quantity 1956*). A preliminary validation of the estimates was performed with historic data collected on Twitchell Island.

Estimating Total Delta Seepage

Total Delta seepage consists of a component that is available for consumptive use by plants and a component that is returned to Delta channels. The current version of DICU adequately accounts for the former component but does not account for the latter component. Both components are necessary in computing accurate diversion and return flows.

To derive an estimate for drained Delta seepage, it was assumed that all agricultural return flows occurring between May and October are composed entirely of seepage and excess applied irrigation water. Return flows during other months are likely to be influenced by precipitation runoff and drainage of leach water. Return flow volume data collected between November 1954 and October 1955 (*Quantity 1956*) were segregated according to the DOC subregions delineated in Figure 5-1. As shown in Figure 5-2 and as calculated in Tables 5-2, 5-3 and 5-4, the high-DOC subregion has the highest drainage on a per unit area basis, followed by the mid-DOC and low-DOC subregions. Although the subregion delineation was not specifically designed to characterize Delta seepage, the pattern shown in Figure 5-2 seems reasonable. The pattern can be explained in part by elevation differences in the Delta. The high-DOC subregion generally corresponds with the low elevation islands, where more seepage is expected due to large hydraulic gradients. Likewise, the low-DOC subregion generally corresponds with the higher elevation islands, where less seepage is expected to occur.

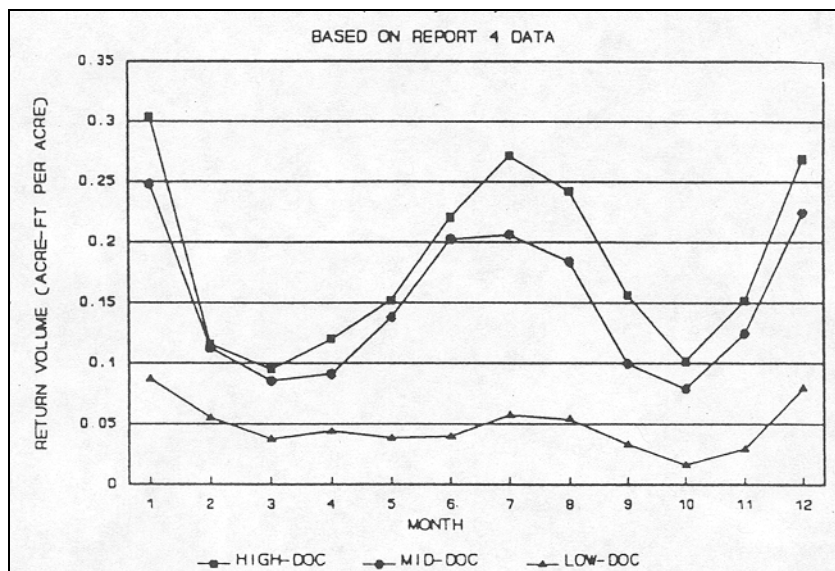


Figure 5-2: Delta Return Flow Unit Volumes
(*Quantity 1956*)

Table 5-2: Drain Volumes in High-DOC Delta Subregion
(acre-ft) (*Quantity* 1956)

UNIT	TOTAL ACRES	NOV 1954	DEC 1954	JAN 1955	FEB 1955	MAR 1955	APR 1955	MAY 1955	JUN 1955	JUL 1955	AUG 1955	SEP 1955	OCT 1955
21	14846	3792	7388	7472	2765	1935	2350	3873	5340	5398	4576	3392	2175
20	21302	5639	10209	14637	3840	2016	3533	6521	10456	11726	11870	8521	3505
18	18504	4025	5759	4836	2425	1942	1439	3509	5603	10156	8081	3432	2884
17	10191	1185	3597	3198	1039	1291	1823	1585	1613	2000	1499	1153	603
16	18343	1076	2804	4008	1470	1041	1854	1707	2457	2336	2044	1811	1511
15	26424	3425	4851	5721	2871	2782	2544	1801	2425	2805	3398	2079	2021
14	14671	1483	2166	1961	1645	1983	2307	1614	1773	2264	846	545	891
9	16085	696	979	841	252	401	1057	742	1301	1408	1647	1067	710
TOTALS	140366	21321	37753	42674	16307	13391	16907	21352	30968	38093	33961	22000	14300
AF/AC	----	0.152	0.269	0.304	0.116	0.095	0.120	0.152	0.221	0.271	0.242	0.157	0.102

Table 5-3: Drain Volumes in Mid-DOC Delta Subregion
(acre-ft) (*Quantity* 1956)

UNIT	TOTAL ACRES	NOV 1954	DEC 1954	JAN 1955	FEB 1955	MAR 1955	APR 1955	MAY 1955	JUN 1955	JUL 1955	AUG 1955	SEP 1955	OCT 1955
26	2810	140	399	412	150	92	95	107	133	155	153	113	93
24	32879	2795	8907	9189	3410	2053	2135	2355	2649	2862	2929	2285	1974
23	24493	3514	9308	11828	3229	2103	1843	2018	2481	2056	2818	1663	1981
22	19357	8637	10635	12773	7385	5127	3949	10734	16862	15557	12826	6142	5302
19	17917	1268	2753	2454	1221	826	1301	2618	3160	3759	3282	1963	1275
13	16641	529	1288	1303	777	767	1081	964	1575	2356	2022	1049	435
12	16877	1481	2916	3105	1689	1690	2582	2171	3921	3927	3690	971	621
11	14365	753	1383	1516	865	637	889	792	1349	1433	1411	591	417
10	11067	313	486	637	352	245	443	535	757	874	860	624	450
8	22103	2867	1917	1046	1086	1752	2018	2354	3267	3817	2830	2411	1577
TOTALS	178509	22297	39992	44263	20164	15292	16336	24648	36154	36796	32821	17812	14125
AF/AC	----	0.125	0.224	0.248	0.113	0.086	0.092	0.138	0.203	0.206	0.184	0.100	0.079

Table 5-4: Drain Volumes in Low-DOC Subregion
(acre-ft) (*Quantity* 1956)

UNIT	TOTAL ACRES	NOV 1954	DEC 1954	JAN 1955	FEB 1955	MAR 1955	APR 1955	MAY 1955	JUN 1955	JUL 1955	AUG 1955	SEP 1955	OCT 1955
27	10148	60	195	264	127	311	722	487	584	948	1209	588	114
25	33212	971	3812	3678	2188	1958	2540	2233	2553	3574	3217	2068	922
7	7510	183	379	669	367	221	229	259	189	214	120	122	59
6	33027	1480	2541	2944	2159	771	401	293	235	314	269	227	320
3	5465	225	387	594	558	475	403	541	401	667	573	299	43
2	11202	0	672	582	90	0	90	0	0	0	0	0	134
TOTALS	100564	2919	7986	8731	5489	3736	4385	3813	3962	5717	5388	3304	1592
AF/AC	----	0.029	0.079	0.087	0.055	0.037	0.044	0.038	0.039	0.057	0.054	0.033	0.016

Data from October 1955 was used to estimate seepage volume in the Delta. During this month, total return flows were at a minimum and excess applied water was expected to be a minor component of total return flow. Hence, the resulting seepage estimate was expected to be relatively insensitive to irrigation efficiency assumptions:

- Estimate total Delta return volume for October 1955 given unit volumes from Figure 3-2:

High-DOC Return Volume = 140,366 acres x 0.102 acre-ft/acre = 14,300 acre-ft

Mid-DOC Return Volume = 178,509 acres x 0.079 acre-ft/acre = 14,100 acre-ft

Low-DOC Return Volume = 100,564 acres x 0.016 acre-ft/acre = 1,600 acre-ft

Total Delta Return Volume = 14,300 + 14,100 + 1,600 = 30,000 acre-ft

which corresponds with the total return volume given in Table 10 of Report 4.

- Estimate excess applied irrigation water for October 1955. Assume a 70% irrigation efficiency and irrigated acreage and applied water volume measured in 1954 per Table 7 of Report 4. Applied water volumes were not measured in 1955:

Excess Applied Water = 291,667 acres x 0.022 acre-ft/acre x (1-0.7) = 1,900 acre-ft

- Estimate Delta seepage that is drained:

Drained Delta Seepage = Total Delta Return Volume - Excess Applied Water =
30,000 - 1,900 = 28,100 acre-ft = 465 cfs (0.067 acre-ft/acre)

- Not all seepage is drained, however. A fraction of seepage is consumptively used by plants. The DICU model predicts that consumptive use of seepage varied between 300-500 cfs during the 1922-92 simulation period (*Estimation 1995*). The model predicts that in October 1955, 495 cfs (0.071 acre-ft/acre) of seepage was consumptively used in the Delta. Therefore:

Total Delta Seepage = Drained Seepage + Consumptively Used Seepage =
465 + 495 = 960 cfs (0.138 acre-ft/acre)

Previous DWR seepage estimates range between 635-840 cfs (*Estimation 1995*).

Estimating Spatial Variation in Irrigation Efficiency

Data in Report 4 suggests spatial variation in irrigation efficiency. For example, in 1954 seasonal applied water values for corn were much higher in the middle organic soils (3.6 acre-ft/acre) than in the north and south mineral soils (1.5 acre-ft/acre). Given the drained seepage estimate developed in the previous section, average and regional irrigation efficiencies were computed for the months May through September. Results are summarized in Fig. 3-3.

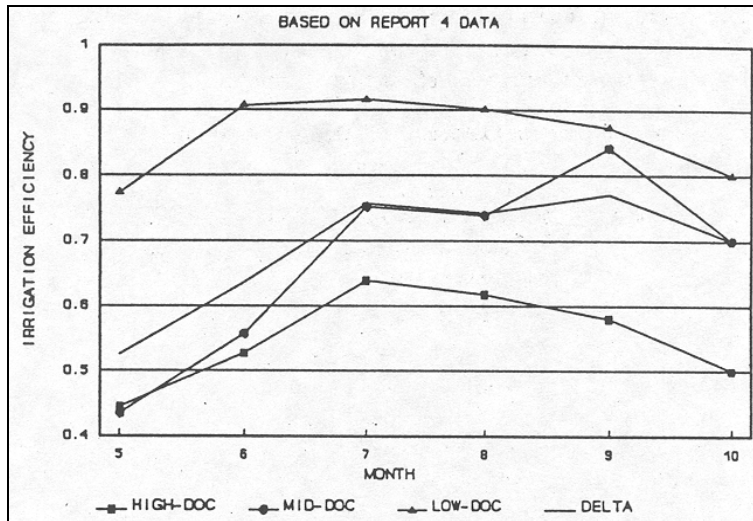


Figure 5-3: Irrigation Efficiency Estimates by Delta Subregion

Delta Average. Assuming drained seepage is constant throughout the year and given unit volumes per Tables 7 and 10 from Report 4, compute irrigation efficiencies:

□ May

Return Volume = 419,439 acres x 0.119 acre-ft/acre = 49,900 acre-ft

Excess Applied Water = 291,667 acres x 0.157 acre-ft/acre x (1 - η)

Drained Seepage = 28,100 acre-ft

$49,900 - 28,100 = 291,667 \times 0.157 \times (1 - \eta) \rightarrow \eta = 0.52$

□ June

Return Volume = 419,439 acres x 0.169 acre-ft/acre = 70,900 acre-ft

Excess Applied Water = 291,667 acres x 0.405 acre-ft/acre x (1 - η)

Drained Seepage = 28,100 acre-ft

$70,900 - 28,100 = 291,667 \times 0.405 \times (1 - \eta) \rightarrow \eta = 0.64$

□ July

Return Volume = 419,439 acres x 0.192 acre-ft/acre = 80,500 acre-ft

Excess Applied Water = 291,667 acres x 0.742 acre-ft/acre x (1 - η)

Drained Seepage = 28,100 acre-ft

$80,500 - 28,100 = 291,667 \times 0.742 \times (1 - \eta) \rightarrow \eta = 0.76$

□ August

Return Volume = 419,439 acres x 0.172 acre-ft/acre = 72,100 acre-ft

Excess Applied Water = 291,667 acres x 0.585 acre-ft/acre x (1 - η)

Drained Seepage = 28,100 acre-ft

$72,100 - 28,100 = 291,667 \times 0.585 \times (1 - \eta) \rightarrow \eta = 0.74$

□ September

Return Volume = 419,439 acres x 0.103 acre-ft/acre = 43,200 acre-ft

Excess Applied Water = 291,667 acres x 0.225 acre-ft/acre x (1- η)

Drained Seepage = 28,100 acre-ft

$43,200 - 28,100 = 291,667 \times 0.225 \times (1 - \eta) \rightarrow \eta = 0.77$

Calculated irrigation efficiencies range between 52-77% and have a weighted average (by unit applied water volume) of 71%. The irrigation efficiency estimates for May through September are fairly insensitive to the assumed value of irrigation efficiency for October since applied water is minimal during October. Varying the October value between 40-80% results in the following variation by month: 48-54% in May; 62-64% in June; 75-76% in July; 73-75% in August; 69-72% in September. The weighted average varies between 69-72%.

DOC Subregions. Irrigation efficiencies were calculated for each DOC subregion by first calculating drainage and applied water factors as shown in Tables 5-2 through 5-7:

- Seepage was computed for the high-DOC subregion seepage assuming a 50% irrigation efficiency and October hydrology. Again, drained seepage is assumed to be constant throughout the year:

Excess Applied Water = 85,263 acres x 0.024 acre-ft/acre x (1-0.5) = 1,000 acre-ft

Drained High-DOC Seepage = High-DOC Return Volume - Excess Applied Water =
 $14,300 - 1,000 = 13,300$ acre-ft (0.095 acre-ft/acre)

□ May

Return Volume = 140,366 acres x 0.152 acre-ft/acre = 21,300 acre-ft

Excess Applied Water = 85,263 acres x 0.171 acre-ft/acre x (1- η)

Drained Seepage = 13,300 acre-ft

$21,300 - 13,300 = 85,263 \times 0.171 \times (1 - \eta) \rightarrow \eta = 0.44$

□ June

Return Volume = 140,366 acres x 0.221 acre-ft/acre = 31,000 acre-ft

Excess Applied Water = 85,263 acres x 0.439 acre-ft/acre x (1- η)

Drained Seepage = 13,300 acre-ft

$31,000 - 13,300 = 85,263 \times 0.439 \times (1 - \eta) \rightarrow \eta = 0.53$

□ July

Return Volume = 140,366 acres x 0.271 acre-ft/acre = 38,000 acre-ft

Excess Applied Water = 85,263 acres x 0.806 acre-ft/acre x (1- η)

Drained Seepage = 13,300 acre-ft

$38,000 - 13,300 = 85,263 \times 0.806 \times (1 - \eta) \rightarrow \eta = 0.64$

❑ August

Return Volume = 140,366 acres x 0.242 acre-ft/acre = 34,000 acre-ft

Excess Applied Water = 85,263 acres x 0.635 acre-ft/acre x (1- η)

Drained Seepage = 13,300 acre-ft

$34,000 - 13,300 = 85,263 \times 0.635 \times (1 - \eta) \rightarrow \eta = 0.62$

❑ September

Return Volume = 140,366 acres x 0.157 acre-ft/acre = 22,000 acre-ft

Excess Applied Water = 85,263 acres x 0.244 acre-ft/acre x (1- η)

Drained Seepage = 13,300 acre-ft

$22,000 - 13,300 = 85,263 \times 0.244 \times (1 - \eta) \rightarrow \eta = 0.58$

Table 5-5: Applied Water Volumes in High-DOC Subregion

(acre-ft) (*Quantity* 1956)

UNIT	IRRIGATED ACRES	MAR 1954	APR 1954	MAY 1954	JUN 1954	JUL 1954	AUG 1954	SEP 1954	OCT 1954
21	10666	210	820	1440	3690	6770	5340	2050	210
20	16534	400	1610	2810	7230	13260	10440	4020	400
18	12792	350	1410	2480	6370	11680	9200	3540	350
17	6130	110	430	760	1950	3580	2820	1080	110
16	13598	330	1340	2330	6000	11000	8660	3330	330
15	13445	400	1580	2770	7130	13070	10300	3960	400
14	4319	90	370	650	1670	3070	2420	930	90
9	7779	190	760	1330	3430	6290	4960	1910	190
TOTAL	85263	2080	8320	14570	37470	68720	54140	20820	2080
AF/AC	----	0.024	0.098	0.171	0.439	0.806	0.635	0.244	0.024

Table 5-6: Applied Water Volumes in Mid-DOC Subregion

(acre-ft) (*Quantity* 1956)

UNIT	IRRIGATED ACRES	MAR 1954	APR 1954	MAY 1954	JUN 1954	JUL 1954	AUG 1954	SEP 1954	OCT 1954
26	651	20	90	150	400	730	570	220	20
24	24156	500	2010	3520	9060	16600	13080	5030	500
23	19812	350	1410	2460	6330	11610	9150	3520	350
22	14465	270	1080	1890	4860	8910	7020	2700	270
19	12943	330	1300	2280	5860	10740	8470	3250	330
13	10413	290	1150	2010	5160	9460	7450	2870	290
12	12916	320	1290	2260	5810	10660	8400	3230	320
11	11142	280	1110	1940	5000	9170	7220	2780	280
10	8447	150	600	1060	2710	4980	3920	1510	150
8	16518	360	1450	2550	6540	11990	9450	3640	360
TOTAL	131463	2870	11490	20120	51730	94850	74730	28750	2870
AF/AC	----	0.022	0.087	0.153	0.393	0.721	0.568	0.219	0.022

Table 5-7: Applied Water Volumes in Low-DOC Subregion
(acre-ft) (*Quantity* 1956)

UNIT	IRRIGATED ACRES	MAR 1954	APR 1954	MAY 1954	JUN 1954	JUL 1954	AUG 1954	SEP 1954	OCT 1954
27	8636	250	990	1730	4440	8150	6420	2470	250
25	25912	530	2120	3700	9530	17460	13760	5290	530
7	6025	130	500	870	2240	4090	3230	1240	130
6	24900	510	2040	3570	9180	16820	13250	5100	510
3	4074	80	320	560	1430	2630	2070	790	80
2	5394	110	460	790	2040	3730	2940	1130	110
TOTAL	74941	1610	6430	11220	28860	52880	41670	16020	1610
AF/AC	----	0.021	0.086	0.150	0.385	0.706	0.556	0.214	0.021

Calculated irrigation efficiencies range between 44-64% and have a weighted average (by unit applied water volume) of 59%. The irrigation efficiency estimates for May through September are fairly insensitive to the assumed value of irrigation efficiency for October. Varying the October value between 40-80% results in the following variation by month: 43-49% in May; 52-54% in June; 64-65% in July; 61-63% in August; 57-61% in September. The weighted average varies between 58-61%.

In a similar manner, drained seepage volumes and monthly irrigation efficiencies were estimated for the mid- and low-DOC subregions. Drained seepage was computed as 13,300 acre-ft (0.074 acre-ft/acre) in the mid-DOC subregion and 1,300 acre-ft (0.013 acre-ft/acre) in the low-DOC subregion. Weighted average irrigation efficiencies were computed as 70% for the mid-DOC subregion and 89% for the low-DOC subregion.

Hence, the high-DOC subregion is characterized by high seepage and low irrigation efficiencies and the low-DOC subregion is characterized by low seepage and high irrigation efficiencies. The mid-DOC subregion is similar to average Delta conditions.

Modifications to Crop-Dependent Irrigation Efficiencies

Assuming that crop-dependent irrigation efficiencies developed for Bulletin 160-93 (*Irrigation 1995*) represent long-term average Delta conditions, weighted average irrigation efficiencies computed in the previous section were corrected to reflect long-term conditions. These irrigation efficiencies are given in Table 5-8:

- According to Table 2 of Report 4, Delta irrigated land use in 1955 was as follows: Asparagus (28%); Corn (16%); Alfalfa (12%); Sugar Beets (10%); Tomatoes (10%); Pasture (8%); Milo (7%); Miscellaneous (9%). With long-term average crop-dependent irrigation efficiencies from Table 3-8 and the above land use information, a long-term weighted average Delta irrigation efficiency was computed:

$$\text{Long-Term Average Irrigation Efficiency} = (.28)(68) + (.16)(69) + (.12)(68) + (.10)(68) + (.10)(68) + (.08)(62) + (.07)(68) + (.09)(68) = 68\%$$

- Recall that a 1954-55 Delta-wide weighted average irrigation efficiency of 71% was computed from data in Report 4. Therefore, weighted averages for each subregion were adjusted downward to reflect a long-term average irrigation efficiency of 68%:

High-DOC Subregion: $59 \times (68/71) = 57\%$

Mid-DOC Subregion: $70 \times (68/71) = 67\%$

Low-DOC Subregion: $89 \times (68/71) = 85\%$

Long-term average crop-varying irrigation efficiencies were modified to reflect spatial variability. Modified irrigation efficiencies by crop and subregion are given in Table 5-8. Average values were reduced by a factor of 0.84 (57/68) for the high-DOC subregion and by a factor of 0.99 (70/71) for the mid-DOC subregion. Average values were increased by a factor of 1.25 (85/68) for the low-DOC subregion, assuming a maximum irrigation efficiency of 90% for safflower.

Table 5-8: Proposed Delta Irrigation Efficiencies (Percentage) of Delta Average
(Irrigation 1995)

Crop	High-DOC Subregion	Mid-DOC Subregion	Low-DOC Subregion	Delta Average
Grain	56	66	84	67
Rice	44	51	65	52
Safflower	66	77	90	78
Sugar Beets	57	67	85	68
Corn	58	68	86	69
Field	57	69	85	68
Alfalfa	57	67	85	68
Pasture	52	61	78	62
Tomatoes	57	67	85	68
Truck	57	67	85	68
Orchard	58	68	86	69
Vineyard	54	63	80	64

Preliminary Validation

The new seepage and irrigation efficiency estimates were compared with Twitchell Island field estimates reported by Owen & Nance (1962). The authors measured identical applied water and return volumes of 425 acre-ft and estimated seepage of 504 acre-ft for the month of October 1960. Twitchell Island lies within the high-DOC Delta subregion and has a total area of 3580 acres. In 1960 the island had 3494 irrigated acres, mainly in corn and grain. Two seepage comparisons were made, the first employing measured applied water and return volumes:

- Estimate excess applied irrigation water and drained seepage assuming a 57% irrigation efficiency for a corn and grain land use per Table 5-8:

Excess Applied Water = $425 \text{ acre-ft} \times (1 - 0.57) = 183 \text{ acre-ft}$

Drained Seepage = Return Volume - Excess Applied Water = $425 - 183 = 242 \text{ acre-ft}$

- Per DICU, seepage available for consumptive use is approximately 250 acre-ft (*Estimation 1995*). Therefore,

$$\text{Total Seepage} = 242 + 250 = 492 \text{ acre-ft}$$

which is within 2% of the Owen & Nance estimate. A second seepage comparison was made employing unit applied water and return volumes:

$$\text{Return Volume} = 3580 \text{ acres} \times 0.102 \text{ acre-ft/acre} = 365 \text{ acre-ft}$$

$$\text{Excess Applied Water} = 3494 \text{ acres} \times 0.024 \text{ acre-ft/acre} \times (1-0.57) = 36 \text{ acre-ft}$$

$$\text{Drained Seepage} = 365 - 36 = 329 \text{ acre-ft}$$

$$\text{Total Seepage} = 329 + 250 = 579 \text{ acre-ft}$$

which is within 15% of the Owen & Nance estimate. Notice the large discrepancy between the excess applied water estimates.

Summary

1. A seepage component that is not available for consumptive use will be added to DICU lowland diversions and return flow computations. This seepage component will not impact hydrodynamics except perhaps in some localized instances, as seepage diversions equal seepage returns. This component will impact water quality, however. The current assumption that no seepage occurs in the Delta uplands will be maintained. The following factors for total monthly seepage into each of the 142 DICU Delta subareas will be used:

$$\text{Total High-DOC seepage} = 0.095 + 0.071 = 0.166 \text{ acre-ft/acre}$$

$$\text{Total Mid-DOC seepage} = 0.074 + 0.071 = 0.145 \text{ acre-ft/acre}$$

$$\text{Total Low-DOC seepage} = 0.013 + 0.071 = 0.084 \text{ acre-ft/acre}$$

Computation of seepage available for consumptive use will remain unchanged from the current DICU formulation. Drained seepage will be calculated as the difference between total seepage and consumptively used seepage.

2. Irrigation efficiency will be allowed to vary by Delta subregion and crop type as given in Table 3-8. These values should be considered subject to further calibration.

Model Calibration

Over the next year, staff will attempt a calibration of the DICU model. Special attention will be given to leach water schedules and irrigation efficiencies. Irrigation efficiencies may be allowed to vary by month as well as by crop and subregion. Allowing crop planting schedules, and thus the annual distribution of evapotranspiration via crop coefficients, to vary for major crops in the Delta will be investigated. Staff will investigate possible correlations between planting

schedules and spring precipitation. Tasks that will be undertaken to support a model calibration, and expected start dates, are given below:

Data Analysis / Acquisition / Assembly

- ❑ Compile applied water estimates from DWR Bulletin 23 series. (May 95)
- ❑ Develop a historic Delta land use database. (Jun 95)
- ❑ Obtain and evaluate Central District's 1990 Delta leach water study. (Jul 95)
- ❑ Compute net channel depletions from AVM data in Old/Middle Rivers. (Jul 95)
- ❑ Obtain power-derived drainage volume estimates from USGS. (Feb 96)

Code Changes

- ❑ Incorporate the Hargreaves-Samani ET formulation. (Jul 95)
- ❑ Allow crop coefficient schedules to vary with spring precipitation. (Jul 95)
- ❑ Allow irrigation efficiency to vary by subarea, crop, and month. (Jul 95)
- ❑ Include leach water in soil moisture calculations. (Jul 95)
- ❑ Modify runoff calculations to be consistent with soil moisture calculations, i.e. drains are operated differently when leaching takes place. (Jul 95)

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